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CALCULATION PACKAGE COVER SHEET

Client: Gowanus Canal Remedial Design Group (RD Group) **Project:** Gowanus Canal Superfund Site **Project #:** HPH106A

TITLE OF PACKAGE: **GLOBAL SLOPE STABILITY ANALYSIS**

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REVISION HISTORY:

NO.	DESCRIPTION	DATE	CP	APC	CC	CA
0	TB4 Pilot Study Design – Issued for Bid	05/19/2017	WT	MS	CPC	JFB

CP: WT	Date: 4/26/2017	APC: MS	Date: 4/26/2017	CC: CPC	Date: 4/26/2017

Client: **RD Group** Project: **Gowanus Canal Superfund Site** Project No: **HPH106A**

GLOBAL SLOPE STABILITY ANALYSIS

INTRODUCTION

The purpose of this "Global Slope Stability Analysis" package is to assess the stability of the dredge slopes formed during dredge operations in support of the remediation cap for the Gowanus Canal (referred to as the Canal). Specifically, the purpose of this package is to present the static slope stability analyses of the dredge slopes after dredging and before cap placement for remediation target area (RTA) RTA1 and the fourth turning basin (TB4). This package presents the calculated factors of safety (FS) for typical 3 horizontal to 1 vertical (3H:1V) dredge slopes and assumed dredge scenarios. This calculation package does not calculate the FS of the existing slopes in the Canal.

The remaining part of this package is organized to present: (i) methodology; (ii) subsurface stratigraphy; (iii) material properties; (iv) analyzed cross sections and scenarios; and (v) results and conclusions.

All elevations presented in this report are based on North American Vertical Datum of 1988 (NAVD 88). Horizontal locations are based on State Plane, NAD 83 New York East, 3101.

Note: Analyses for cap placement and final cap stability will be performed in other separate calculation packages.

METHODOLOGY

Static slope stability analyses were performed using Spencer's method [Spencer, 1973], as implemented in the computer program SLIDE, version 6.039 [Rocscience, 2016].

In general, selection of a slope stability method depends on the accuracy of the analytical derivation of the method as well as the numerical implementation in a slope stability program. SLIDE offers nine separate methods to analyze slope stability. Ordinary or Fellenius and Simplified Bishop [Bishop, 1955] methods satisfy only force equilibrium in one direction and moment equilibrium. Janbu's simplified [Janbu, 1973], Corps of Engineers' (#1 and #2), and Lowe-Karafiath methods satisfy only force equilibrium in two directions. Janbu's corrected method as implemented in SLIDE uses a modification factor to correct the factor of safety to indirectly account for moment equilibrium. Spencer's, General Limit Equilibrium (GLE), and Morgenstern-Price methods satisfy force equilibrium in two directions and moment equilibrium. The implementation of the GLE method in SLIDE is essentially the same as the Morgenstern-Price method. Based on the number of equilibrium equations satisfied, Spencer's and GLE/Morgenstern-Price methods are the most rigorous methods available. In this package, the Spencer's method was chosen as the standard method for performing slope stability analyses for potential failure surfaces.

Rotational type failure mode (i.e., circular slip surfaces) and block type failure surfaces using the optimization option in SLIDE were considered to assess the slope stability FS at the selected cross sections. The SLIDE program generated several potential slip surfaces, calculated the FS for each of these surfaces, and identified the most critical slip surface (i.e., the slip surface with the lowest FS). Information required for the analyses included:

- geometry of the slope;
- subsurface soil stratigraphy;
- water elevation;
- properties of subsurface materials; and
- external loading and support conditions, if any.

As discussed in "Draft Basis of Design Report Section 7 – Capping" [Geosyntec, 2016a] target FS of 1.5 and 1.3 were selected for the long-term and interim (stability during dredging, construction and end of construction) static slope stability conditions of the dredge slopes, respectively.

SUBSURFACE STRATIGRAPHY

Detailed information regarding the subsurface stratigraphy is presented in the calculation packages "Summary of Subsurface Stratigraphy" [Geosyntec, 2016b] and "Summary of Geotechnical Design Parameters" (herein referred to as the Data Package) [Geosyntec, 2016c]. In summary, the Canal subsurface stratigraphy can be broadly divided into three (3) units: soft sediment, native alluvial sediment and glacial deposit. The subsurface profile of the Canal was developed based on the elevation of each layer from the boring logs and cone penetration tests [Geosyntec, 2016b].

Figures 1 and 2 present the thickness and elevation of the bottom of the soft sediment and native alluvial sediment in TB4. From these figures, it is observed that in TB4, the bottom of soft sediment is between approximately elevation -12 feet (ft) to -19 ft, with thickness of soft sediment varying from two feet to about 18 ft. The bottom of native alluvial sediment in TB4 is between approximately elevation -16.5 ft to -30 ft.

Figure 3 presents the thickness of soft sediment and native alluvial sediment in RTA1. From this figure, it is observed that the thickness of the soft sediment in RTA1 varies from two feet to about 20 ft. The thickness of native alluvial sediment in TB4 varies from about one foot to 15 ft.

Figures 4a and 4b present the slope of the existing canal bathymetry in RTA1 and TB4. From these figures, it is observed that most of the steeper slopes are present along the bulkheads. In RTA1, there are a few steep slopes close to the Carroll street bridge.

MATERIAL PROPERTIES

Detailed information related to the selection of the subsurface material properties of the Canal soils was presented in the Data Package [Geosyntec, 2016c]. Table 1 summarizes the selected material properties of each of the subsurface Canal soils. The undrained shear strength of native alluvial sediments in RTA1 was conservatively assumed to be 250 psf for slope stability analyses. For purposes of modelling in SLIDE, the soft sediment was discretized into two-foot thick layers and a constant undrained shear strength corresponding to the selected design undrained shear strength ratio of 0.3 was assigned to each layer.

From the Data Package [Geosyntec, 2016c] it is observed that while most of the soft sediment is slowly draining, some of it could be fast draining. Similarly, not all the native alluvial sediment is either slow draining or fast draining. Hence slope stability analyses were performed using the following shear strength combinations:

- undrained shear strength (UD) of both soft sediment and native alluvial sediment;
- UD of soft sediment and drained shear strength (D) of native alluvial sediment;
- D of soft sediment and UD of native alluvial sediment; and
- D of both soft sediment and the native alluvial sediment.

For each of the strength combination discussed above, the minimum calculated FS for each of the scenarios discussed in the previous section is reported in this package.

ANALYZED CROSS SECTIONS AND SCENARIOS

TB4

Figure 5 presents the plan view of the eleven cross sections (CS) selected initially for static slope stability analysis. Figure 6 presents the profile views of these cross sections (CS-A to CS-K). Slope stability analyses were performed on five out of the eleven cross sections (CS-C, CS-D, CS-G, CS-H, and CS-I) as per the dredging scenario described below.

The final dredge elevations before placement of the remedial cap in TB4 are -15 ft approximately between station (Sta.) 270 and Sta. 500, and -16 ft between Sta. 500 and Sta. 700. To achieve either of these, the dredge scenario involves three steps:

- Step 1: The first step involves dredging a 40-ft wide access channel to elevation -8.57 ft in the Canal from the mouth of TB4 (approximately at Sta. 0 of CS-I in Figure 6) to the end of TB4 (approximately at Sta. 700). This dredge elevation provides a six-foot draft at the low tide (elevation -2.57 ft) in the Canal providing sufficient draft for the dredge equipment to go through.

- Step 2: The second step involves dredging a transition slope from elevation -8.57 ft to elevation -15 ft between CS-C and CS-D.

- Step 3: The third step involves dredging the area between CS-D to CS-H to the final dredge elevation of -15 ft or -16 ft depending on location, as shown on the construction drawings and also mentioned above.

Of the three steps discussed above, critical slopes for dredge slope stability are anticipated in steps 1 and 2. The specific scenarios in TB4 for which static slope stability analyses were assessed are:

- side slope stability of 3H:1V slopes at CS-C, CS-D, CS-G, and CS-H for a dredge elevation of -8.57 ft; and

- slope stability along the Canal of a 3H:1V slope from an elevation of -8.57 ft to -15 ft at CS-I at Sta. 300 in Figure 6 (i.e., at CS-D).

Note that no dredging is required at CS-A and CS-B (Figure 6) to create the 40-ft wide access channel since there is sufficient clearance at these locations.

RTA1

Figure 7 presents a plan view of the selected cross sections for slope stability analysis in RTA1. Figure 8a, 8b and 8c present the profile views of the three selected cross sections in RTA1 (i.e., CS-A, CS-B, and CS-C). In RTA1, the anticipated dredge elevation is the bottom of the soft sediment. The dredge scenario analyzed in RTA1 involved dredging all the soft sediment across the entire Canal except at the locations close to the bridges.

The three bridges in RTA1 are located approximately between Sta. 879 to Sta. 930 (Union Street Bridge), Sta. 1400 to Sta. 1460 (Carroll Street Bridge) and Sta. 2227 to Sta. 2226 (3rd Street Bridge). The location of the bridges and assumed dredge slopes is also shown on Figures 8a, 8b and 8c. It was assumed that 3H:1V slopes will be initially dredged at a distance equal to 50 ft from the edge of the bridges leaving some soft sediment in place. If the calculated FS of these dredged slopes is below selected target FS, the dredge slopes will be adjusted to achieve the target FS.

Slope stability analysis for RTA1 dredge slopes (3H:1V) was performed for CS-A, CS-B and CS-C to an elevation equal to the bottom of soft sediment at:

- north facing slopes: stations 829, 1350, 2177; and
- south facing slopes: stations 980, 1510, 2316.

Based on slope stability analysis results presented later in this package, the short-term target FS requirement was not met for the south facing slope at Sta. 1510. Hence the dredge slope at Sta. 1510 was moved to Sta. 1520 with an assumed compound dredge slope (4H:1V for the upper two feet of soft sediment followed by a 3H:1V slope at remaining depths).

RESULTS AND CONCLUSIONS

Static slope stability analyses on design dredge slopes in TB4 and assumed dredge slopes in RTA1 were performed on selected cross sections for the dredge scenarios described above using the material properties discussed in the Data Package [Geosyntec, 2016c]. The major results and conclusions from the analyses performed are summarized below.

TB4

Table 2 presents the calculated FS for the TB4 analyzed cross sections and scenarios discussed earlier in this package. Figures 9, 10 and 11 show typical calculated critical slip surfaces in TB4.

For the 3H:1V dredge slopes and dredge elevations, the calculated FS was greater than the selected target FS at all cross section locations, except at CS-H. For the left slope (i.e., slope along the northern bulkheads of TB4) of CS-H, the calculated FS is 1.28, just less than the target FS of 1.30 (Figure 9). For this case, the slip surface is shallow (depth is less than two feet) and thus, it is not deemed critical. The calculated FS of a slip surface at the same slope that is deeper than two feet is 1.70 (also shown in Figure 9).

RTA1

Table 3 presents the calculated FS for the RTA1 analyzed cross sections and scenarios discussed earlier in this package. Figures 12, 13 and 14 show typical calculated critical slip surfaces in RTA1.

For the assumed 3H:1V dredge slopes, the calculated FS is greater than the selected target FS at all cross section locations except for the south facing slope at Sta. 1510. At this location, to achieve a calculated FS greater than the target value, the distance between the edge of the bridge to the assumed dredge slope station was increased from 50 ft to 60 ft (i.e., from Sta. 1510 to Sta. 1520) with an assumed 4H:1V dredge slope for the upper two feet of dredge followed by a 3H:1V dredge slope for the rest of the slope.

REFERENCES

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TABLES

Table 1. Selected Material Parameters for Dredge Slopes Stability Evaluation [Geosyntec, 2016c]

Material	Total Unit Weight (pcf)	Drained Shear Strength - Effective Stress Friction Angle, φ' (degrees) Fully Softened Shear Strength[2]	Undrained Shear Strength, S_u (psf)	Undrained Shear Strength Ratio (S_u/σ'_v)	Over Consolidation Ratio (OCR)[1]	Modified Compression Index, $C_{c\varepsilon}$	Modified Recompression Index, $C_{r\varepsilon}$	Modified Secondary Compression Index, $C_{\alpha\varepsilon}$	Coefficient of Consolidation, C_v (cm^2/s)	Young's Modulus (tsf)
Soft Sediment	80	28°	-	0.3	1	0.23	0.028	0.015	1×10^{-4}	-
Native Alluvial Sediment	115	28°	RTA1: 250 psf [> El. -20 ft] 500 psf [< El. -20 ft] TB4: 500 psf [> El. -19 ft and < El. -26 ft] 250 psf [in-between El. -19 ft and -26 ft]	-	1	0.075	0.028	0.002	2×10^{-3}	-
Glacial Deposit	125	34° (effective friction angle in drained and undrained conditions)[3]			1					400

Notes:
1. The soils are assumed to be normally consolidated under the existing conditions.
2. The fully softened shear strength is recommended as the drained shear strength for soft sediment and native alluvial sediment if these soils have not undergone failure.
3. For the glacial deposit, the selected drained and undrained shear strengths are the same as this material is assumed to be freely draining.

Legend:
S_u – Undrained Shear Strength
σ'_v – In-Situ Effective Vertical Stress
pcf – Pounds per Cubic Foot
cm^2/s – Square Centimeter per Second
tsf – Tons per Square Foot
El. – Elevation
ft – feet
RTA – Remediation Target Area
TB4 – 4th Turning Basin

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Table 2. Calculated Factors of Safety for Selected Cross Sections and Scenarios in TB4

Location	Description	Cross Section[3]	Strength[4]	Dredge Elevation	Target FS	Calculated FS	
						Left Slope[6]	Right Slope[6]
TB4	Side Slope Stability[1]	CS-C (3H:1V dredge slope)	UD-UD	-8.57 ft	1.30	2.21	3.86
			UD-D			2.21	3.86
			D-UD		1.50	1.60	1.60
			D-D			1.60	1.60
		CS-D (3H:1V dredge slope)	UD-UD	-8.57 ft	1.30	1.72	1.30
			UD-D			1.72	1.30
			D-UD		1.50	1.60	1.60
			D-D			1.60	1.60
		CS-G (3H:1V dredge slope)	UD-UD	-8.57 ft	1.30	1.30	1.36
			UD-D			1.30	1.36
			D-UD		1.50	1.60	1.60
			D-D			1.60	1.60
		CS-H (3H:1V dredge slope)	UD-UD	-8.57 ft	1.30	1.28/1.70[7]	1.37
			UD-D			1.28/1.70[7]	1.37
			D-UD		1.50	1.60	1.60
			D-D			1.60	1.60
	Along the Canal Slope Stability[2]	CS-I (3H:1V dredge slope)	UD-UD	Variable[5]	1.30	3.33	
			UD-D			1.60	
			D-UD		1.50	1.60	
			D-D			1.60	

Notes:

1. The side slopes are referred to the slopes perpendicular to TB4 and along the bulkheads on the northern and southern edges of TB4. These slopes are formed by excavating a channel along the center of TB4.
2. This is the stability of the dredge slopes along TB4.
3. Plan view and profile views of these cross sections are presented in Figures 5 and 6.
4. The first strength type refers to the soft sediment shear strength while the second strength type refers to the native alluvial sediment shear strength type (e.g., UD-D means undrained shear strength for soft sediment and drained shear strength for native alluvial sediment).
5. For this slope the dredge elevation is varies from -8.57 ft to -15 ft and from -15 ft to -16 ft with a dredge slope of 3H:1V.
6. The left slopes are the slopes along the northern bulkheads of TB4. The right slopes are the slopes along the southern bulkheads of TB4.
7. The calculated FS of 1.28 is for a shallow slip surface (depth less than two feet). For a slip surface deeper than two feet, the calculated FS is 1.70.

Legend:

TB4 – 4th Turning Basin
CS - Cross Section
UD - Undrained Shear Strength
D - Drained Shear Strength
ft - feet
FS - Factor of Safety

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Table 3. Calculated Factors of Safety for Selected Cross Sections and Scenarios in RTA1

Location	**Description**	**Cross Section[2]**	**Strength**	**Dredge Elevation**	**Target FS**	**Calculated FS[3]**						
						Union State Bridge		Carroll Street Bridge			3rd Street Bridge	
						Station 829	Station 980	Station 1350	Station 1510	Station 1520[6]	Station 2177	Station 2316
RTA1	Along Canal Slopes (3H:1V Slopes)[1,6]	CS-A	UD-UD	Bottom of Soft Sediment	1.30	1.60	1.44	1.53	1.47	1.81	1.44	1.51[4]
			UD-D			1.60	1.44	1.53	1.47	1.80	1.44	1.51[4]
			D-UD		1.50	1.60[5]						
			D-D									
		CS-B	UD-UD	Bottom of Soft Sediment	1.30	1.51[4]	1.36[4]	1.46	1.48	1.40	1.46	1.41
			UD-D			1.52[4]	1.36[4]	1.46	1.48	1.40	1.46	1.41
			D-UD		1.50	1.60[5]						
			D-D									
		CS-C	UD-UD	Bottom of Soft Sediment	1.30	1.44	1.46	1.46	1.24[6]	1.55	1.44	2.81[4]
			UD-D			1.44	1.46	1.46	1.24[6]	1.55	1.44	2.15[4]
			D-UD		1.50	1.60[5]						
			D-D									

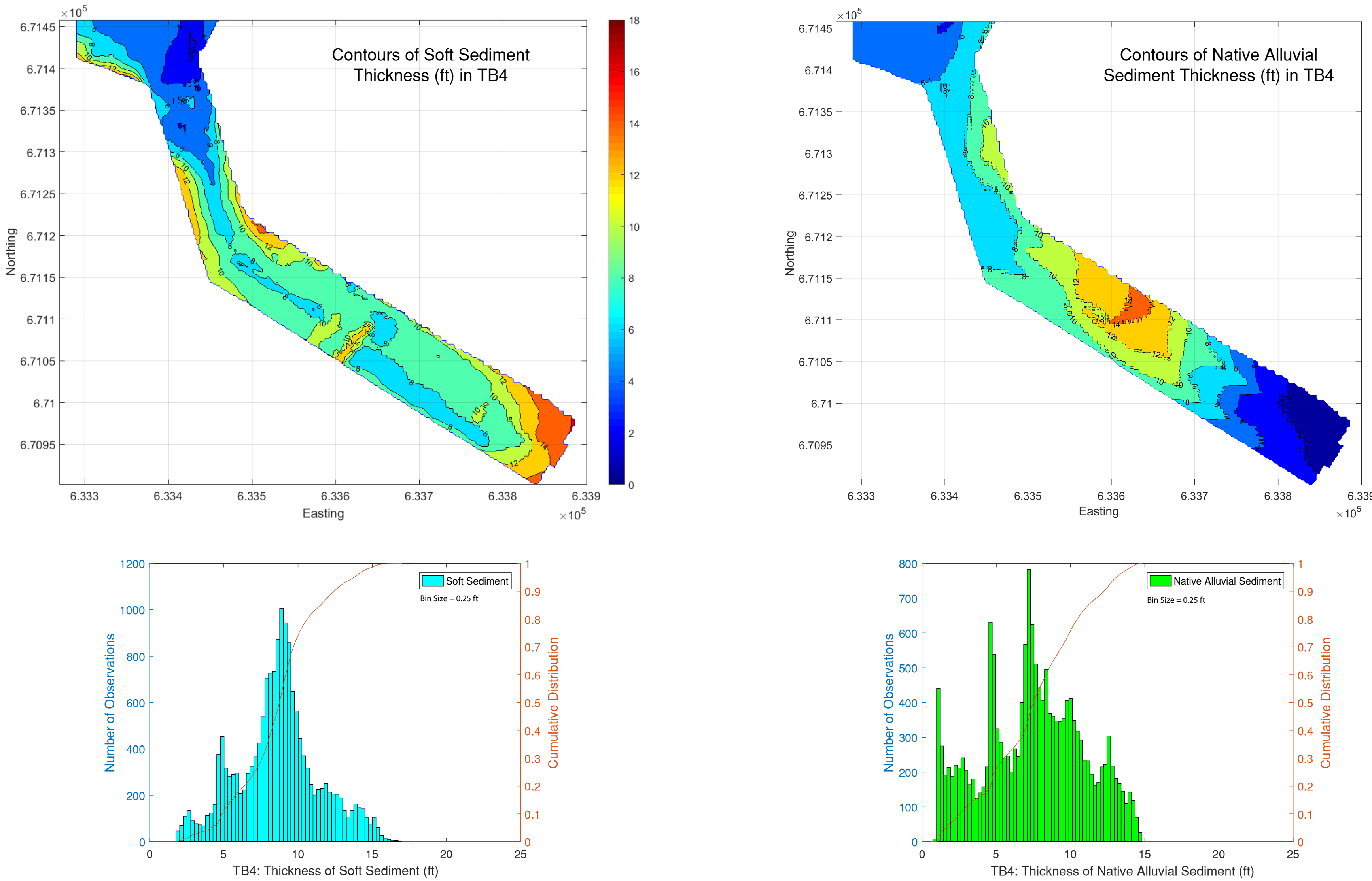
Notes:

1. These slopes are along the canal axis in RTA1.
2. Plan view and profile views of these cross sections are presented in Figures 7 and 8a, 8b and 8c.
3. Maximum depth of slip surface is less than 2 ft, unless otherwise indicated.
4. Depth of slip surface is greater than 4 ft.
5. Sloughing failure surface on face of dredged slope.
6. Based on slope stability analysis results presented in this table the short-term target FS requirement was not met for the south facing slope at Sta. 1510. Hence the dredge slope at Sta. 1510 was moved to Sta. 1520 with an assumed compound dredge slope (4H:1V for the upper two feet of soft sediment followed by a 3H:1V slope at remaining depths).

Legend:

RTA1 - Remediation Target Area 1
CS - Cross Section
UD - Undrained Shear Strength
D - Drained Shear Strength
ft - feet
FS - Factor of Safety

FIGURES



Notes:

1. The soft sediment, native alluvial sediment and glacial deposit interface elevations were obtained from the calculation package titled "Summary of Subsurface Stratigraphy" prepared by Geosyntec [Geosyntec, 2016b].

Thickness of Soft Sediment and Native Alluvial Sediment in TB4

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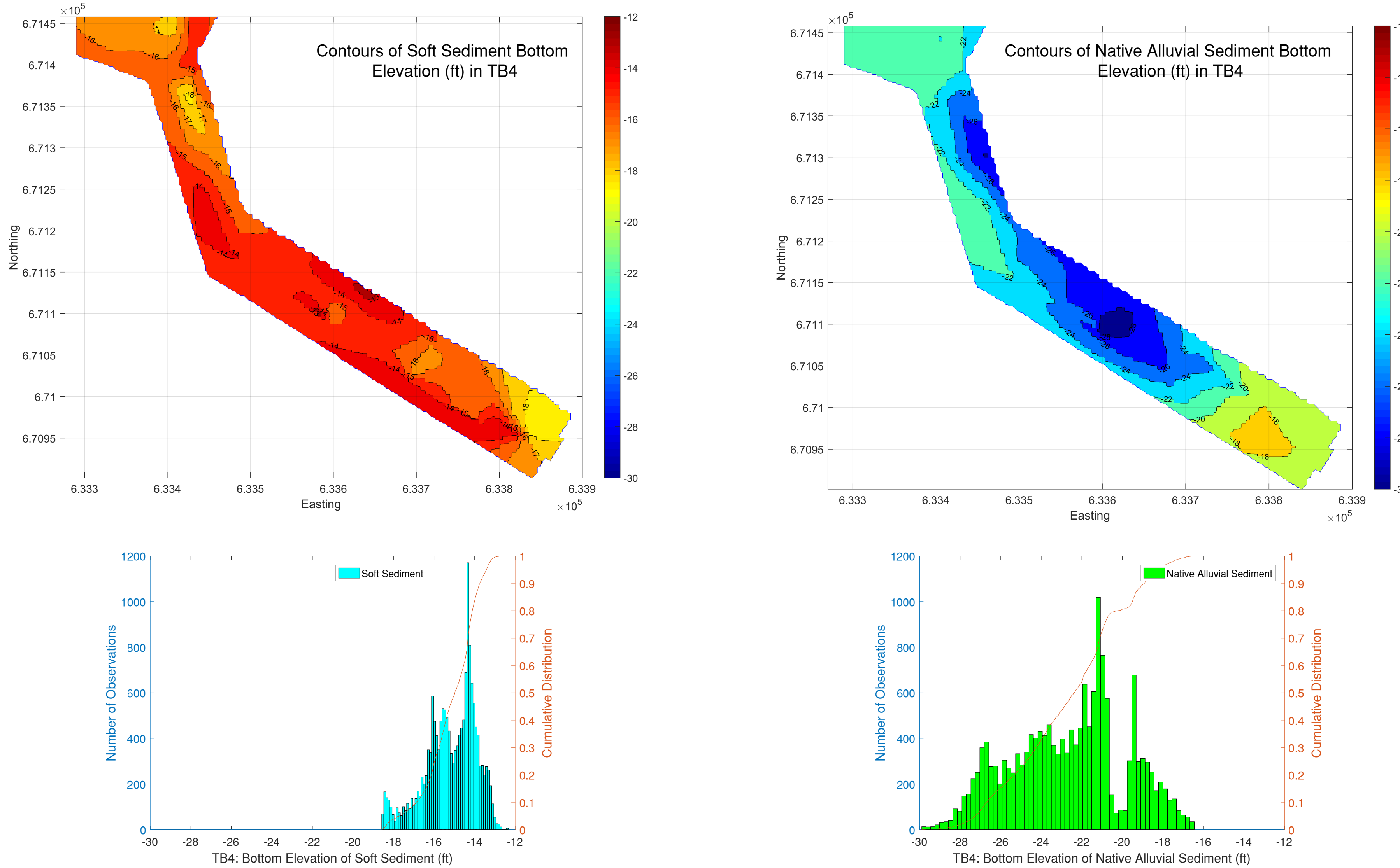
Figure 1



Notes:

1. The soft sediment, native alluvial sediment and glacial deposit interface elevations were obtained from the calculation package titled "Summary of Subsurface Stratigraphy" prepared by Geosyntec [Geosyntec, 2016b].

Bottom Elevation of Soft Sediment and Native Alluvial Sediment in TB4

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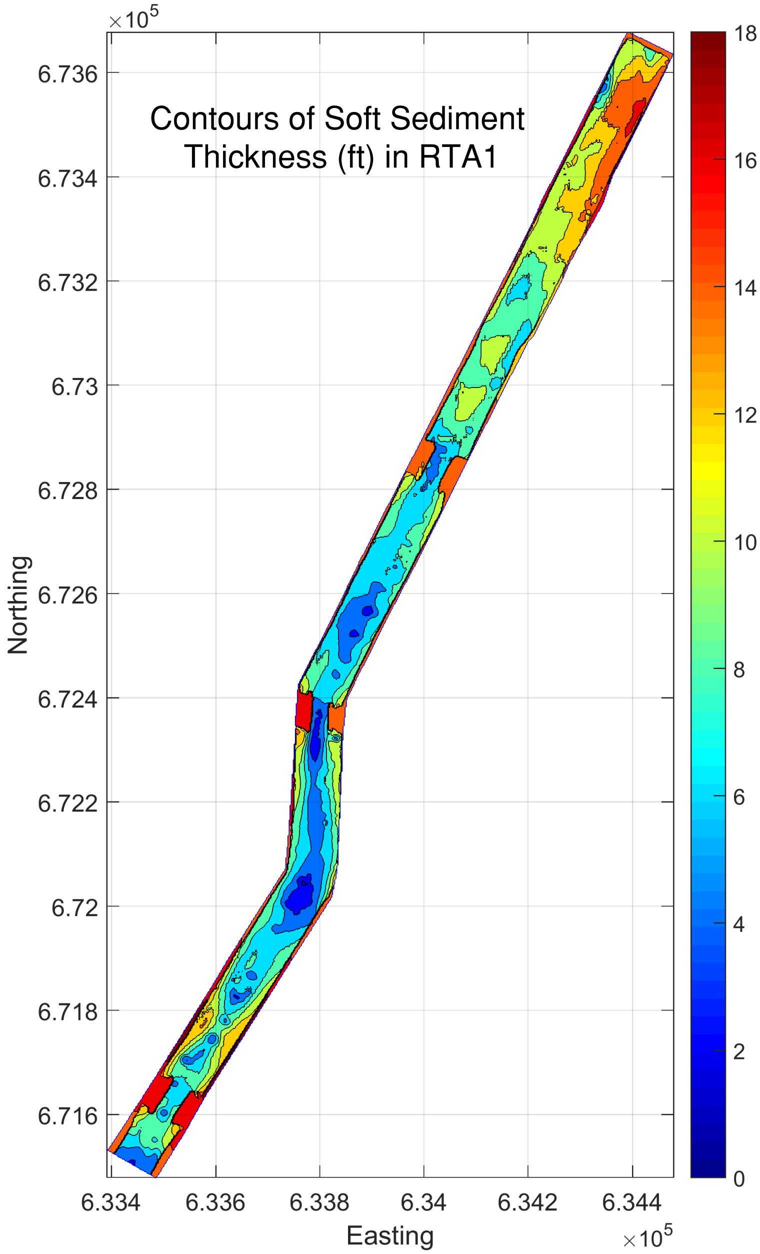

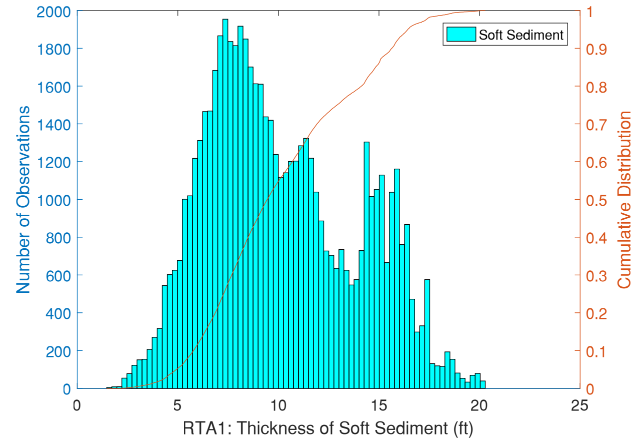

Notes:
1. The soft sediment, native alluvial sediment and glacial deposit interface elevations were obtained from the calculation package titled "Summary of Subsurface Stratigraphy" prepared by Geosyntec [Geosyntec, 2016b].

Thickness of Soft Sediment in RTA1

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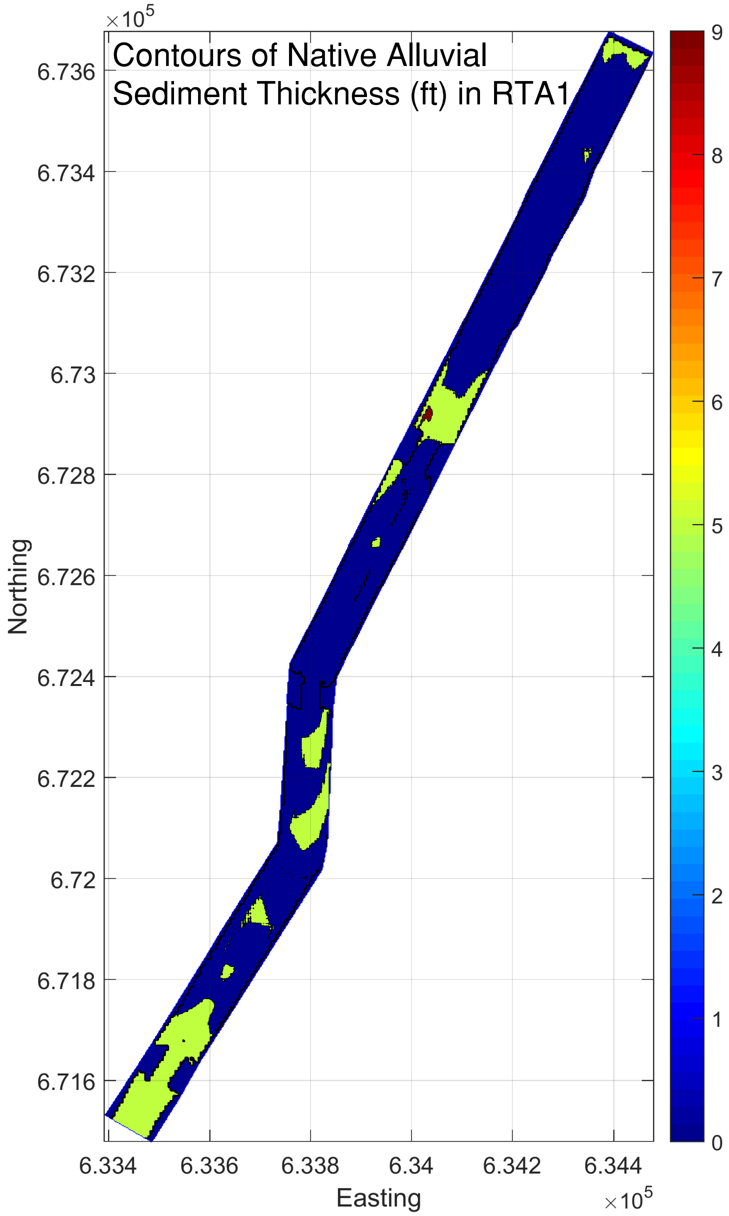
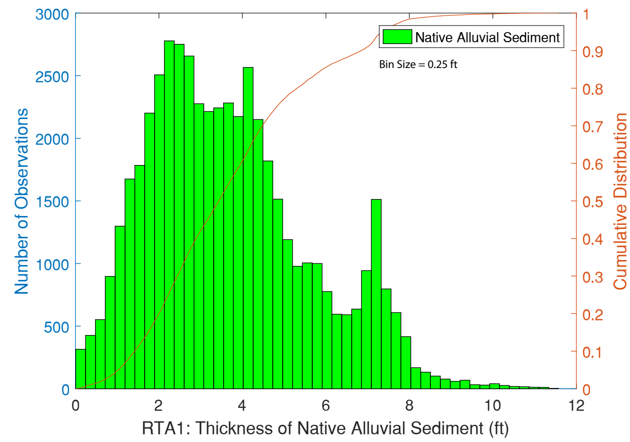
Figure 3a





Notes:
1. The soft sediment, native alluvial sediment and glacial deposit interface elevations were obtained from the calculation package titled "Summary of Subsurface Stratigraphy" prepared by Geosyntec [Geosyntec, 2016b].

Thickness of Native Alluvial Sediment in RTA1

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Figure 3b

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\\Gowanus-01\PRJ\03_GIS\mxd\geotech\SLIDE\RTA1_Bathymetry_slope.mxd; 05/19/2016

Legend

Gowanus Canal

Slope of Bathymetry (Degrees)

- 0 - 3.9
- 4 - 7.9
- 8 - 13.4
- 13.5 - 22.7
- 22.8 - 58.9

375 187.5 0 375 Feet

Slope of Canal Bathymetry - RTA1

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Figure 4a

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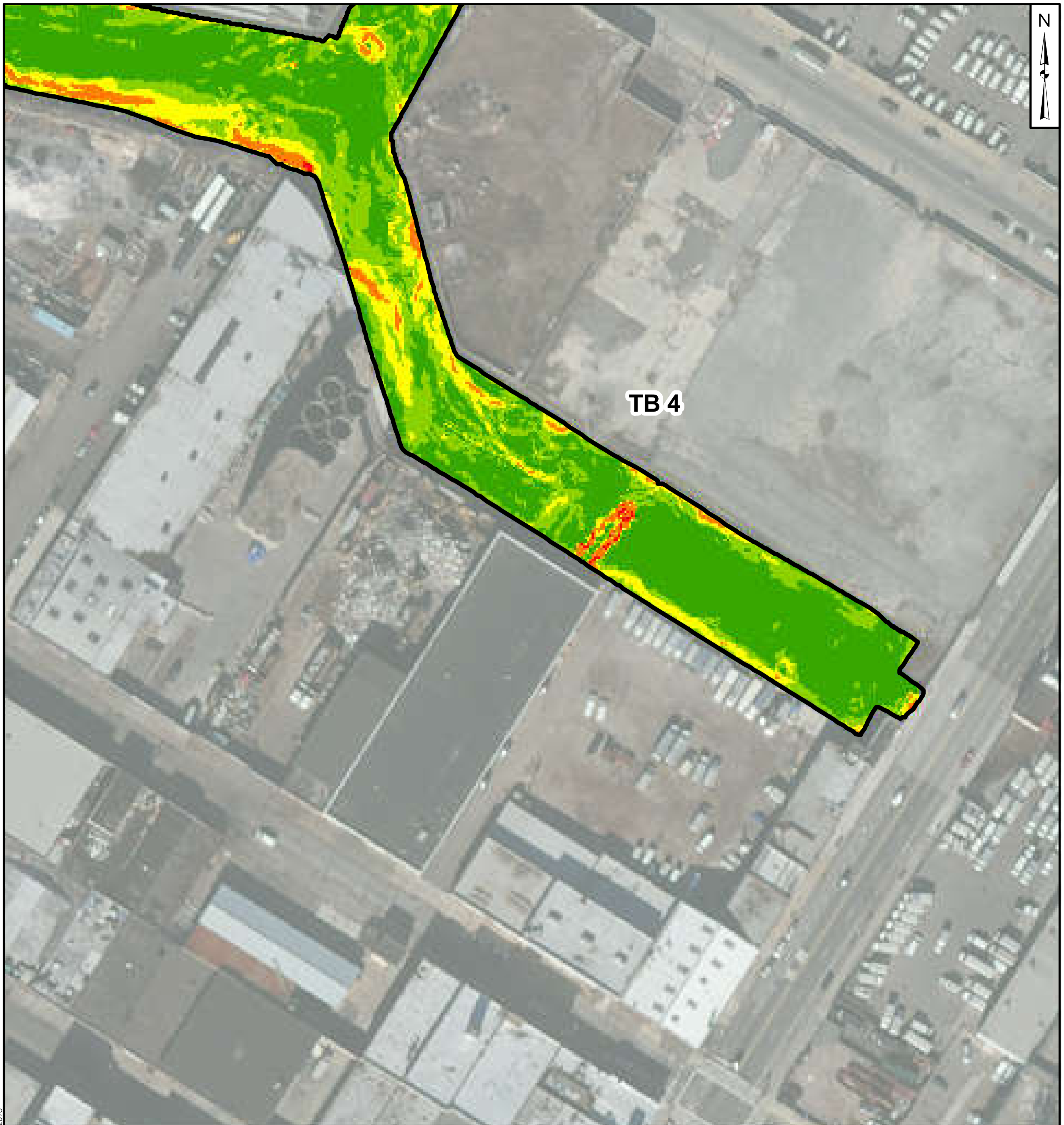

Legend

Gowanus Canal

Slope of Bathymetry

- 0 - 5
- 5.1 - 11.2
- 11.3 - 19.9
- 20 - 37.6
- 37.7 - 79.3

125 62.5 0 125 Feet

Slope of Canal Bathymetry - TB4

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Figure **4b**

\\Gowanus-01\PRJ\03_GIS\mxd\geotech\SLIDE\TB4_Bathymetry_slope.mxd; 05/19/2016

Legend

Cross Section Location

RTA 1

RTA 2

200 100 0 200 Feet

Plan View of Selected Cross Sections for Dredge Slope Stability in TB4

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Figure 5

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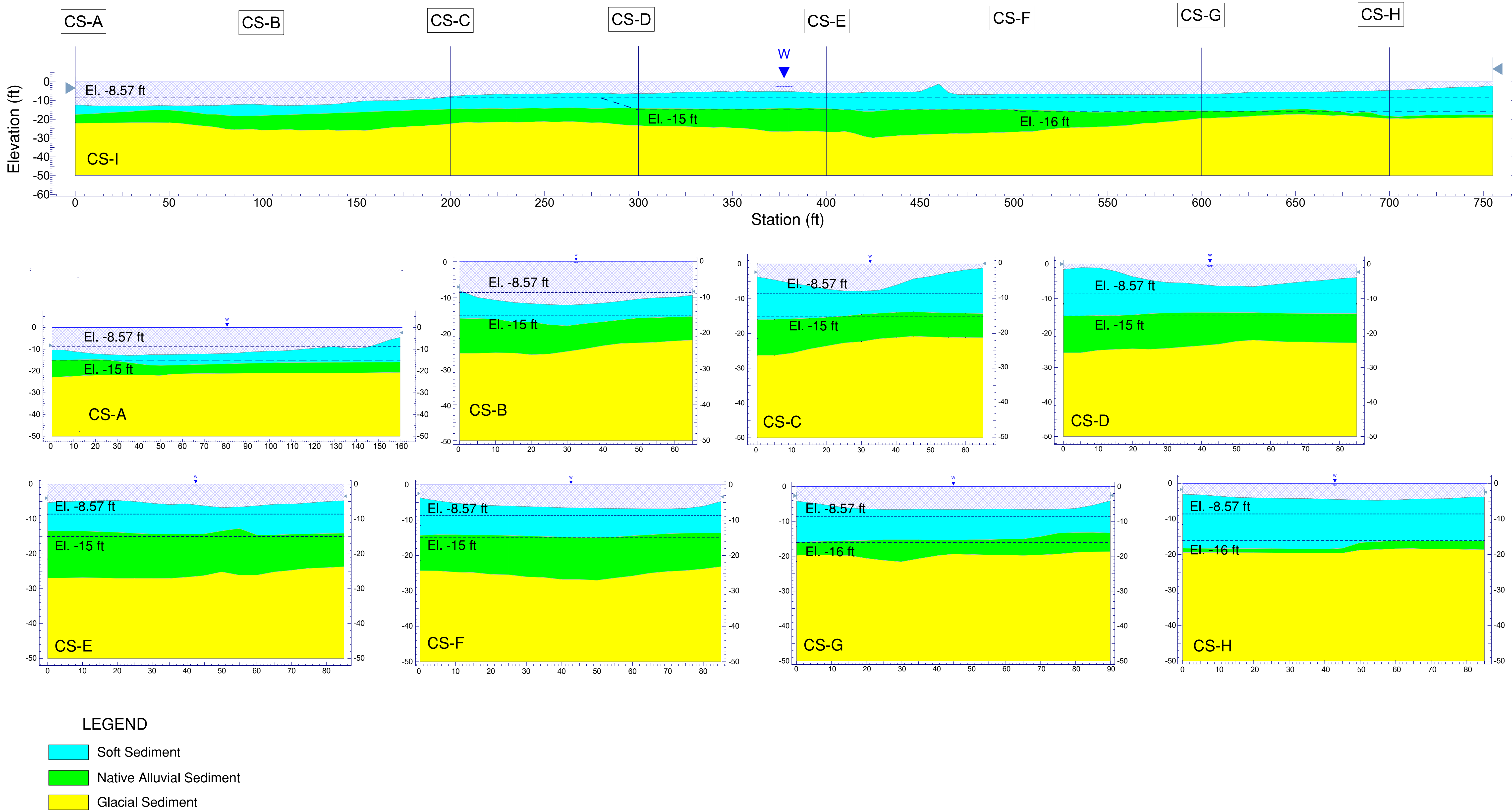

Notes:

1. The soft sediment, native alluvial sediment and glacial deposit interface elevations were obtained from the calculation package titled "Summary of Subsurface Stratigraphy" prepared by Geosyntec [Geosyntec, 2016b].
2. The minimum required draft for dredge operations is assumed to be 6 ft. The mean low tide level in the Canal is at elevation -2.57 ft.

Profile Views of Selected Cross Sections For TB4 Dredge Stability Analyses

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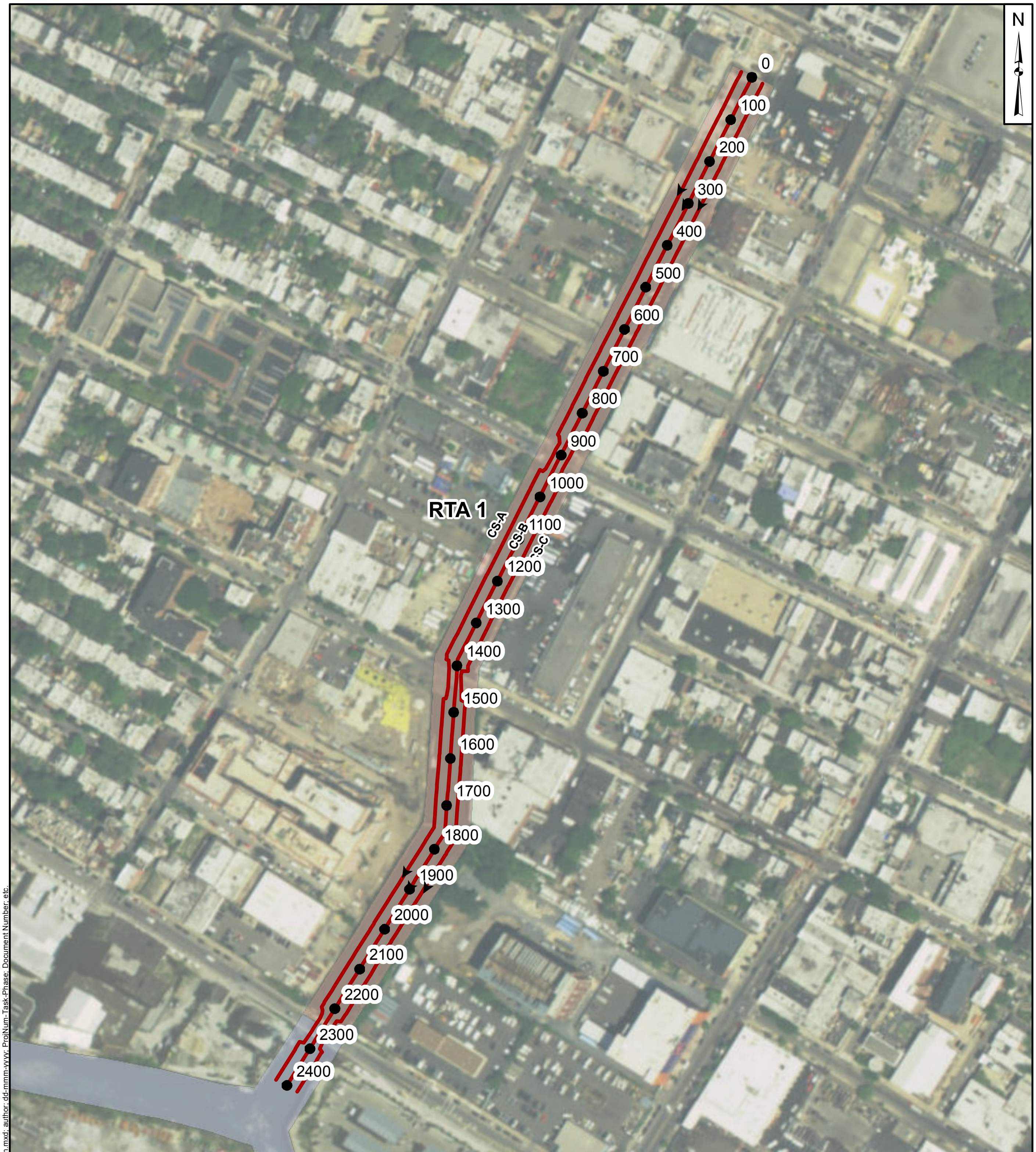
Figure 6



X:\03_GIS\mxd\geotech\SLIDE\Geotech_Figure 8_SLIDE_RTA1_Xsection.mxd; author; dd-mmm-yyyy; ProjNum-Task-Phase; Document Number; etc.

Legend

- Station
- Cross-Section Location
- RTA 1
- RTA 2

300 150 0 300 Feet

Plan View of Selected Cross Sections For Slope Stability in RTA1

Gowanus Canal Superfund Site, Brooklyn, NY

Gowanus Canal Remedial Design Group

Geosyntec consultants

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Figure 7

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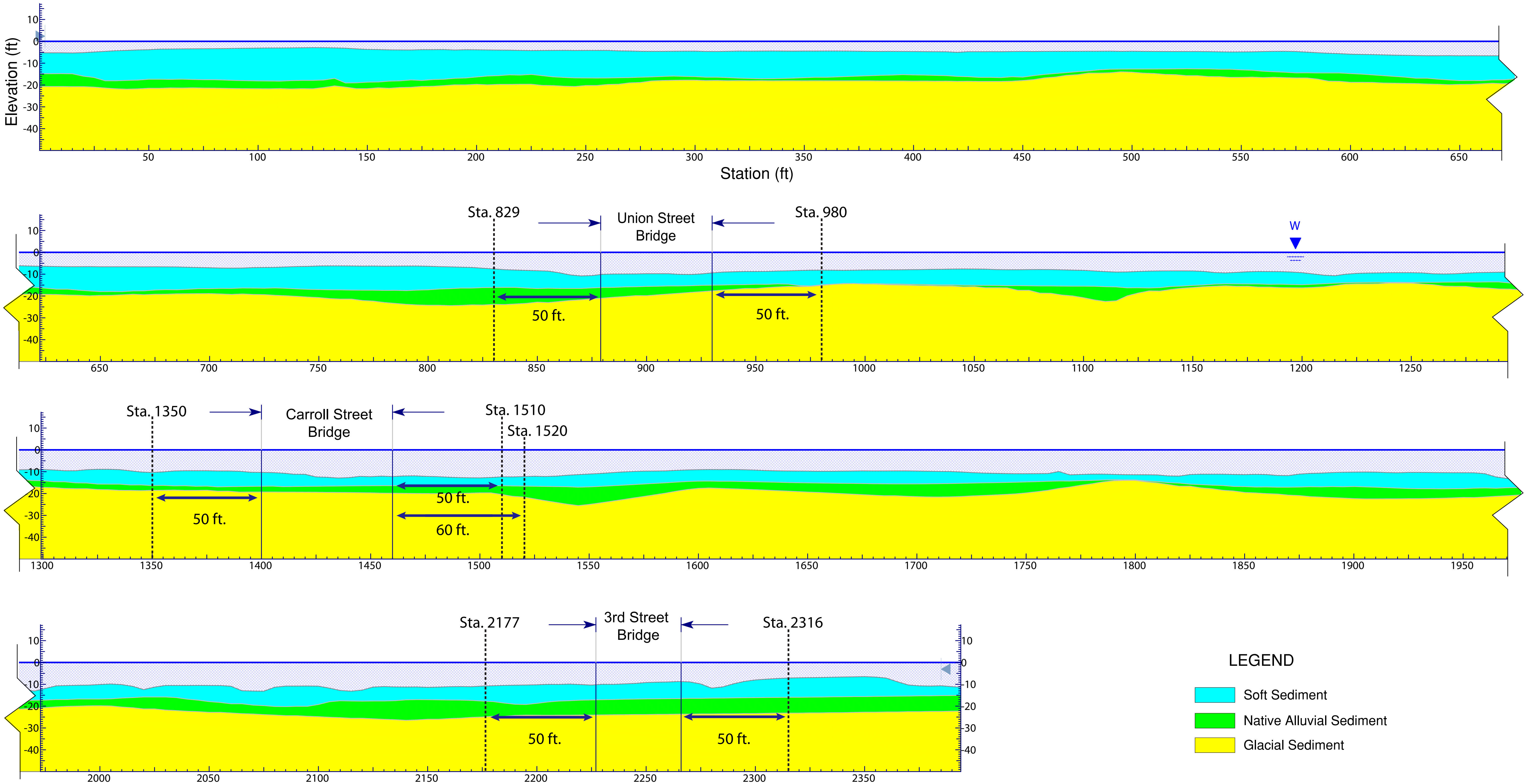

Notes:
1. The soft sediment, native alluvial sediment and glacial deposit interface elevations were obtained from the calculation package titled "Summary of Subsurface Stratigraphy" prepared by Geosyntec [Geosyntec, 2016b].
2. Static slope stability analyses for assumed dredge slopes were performed at Sta. 829, 980, 1350, 1510, 1520, 2177 and 2316.

Profile View of CS-A in RTA1 Showing Locations of Dredge Slope Stability Analyses

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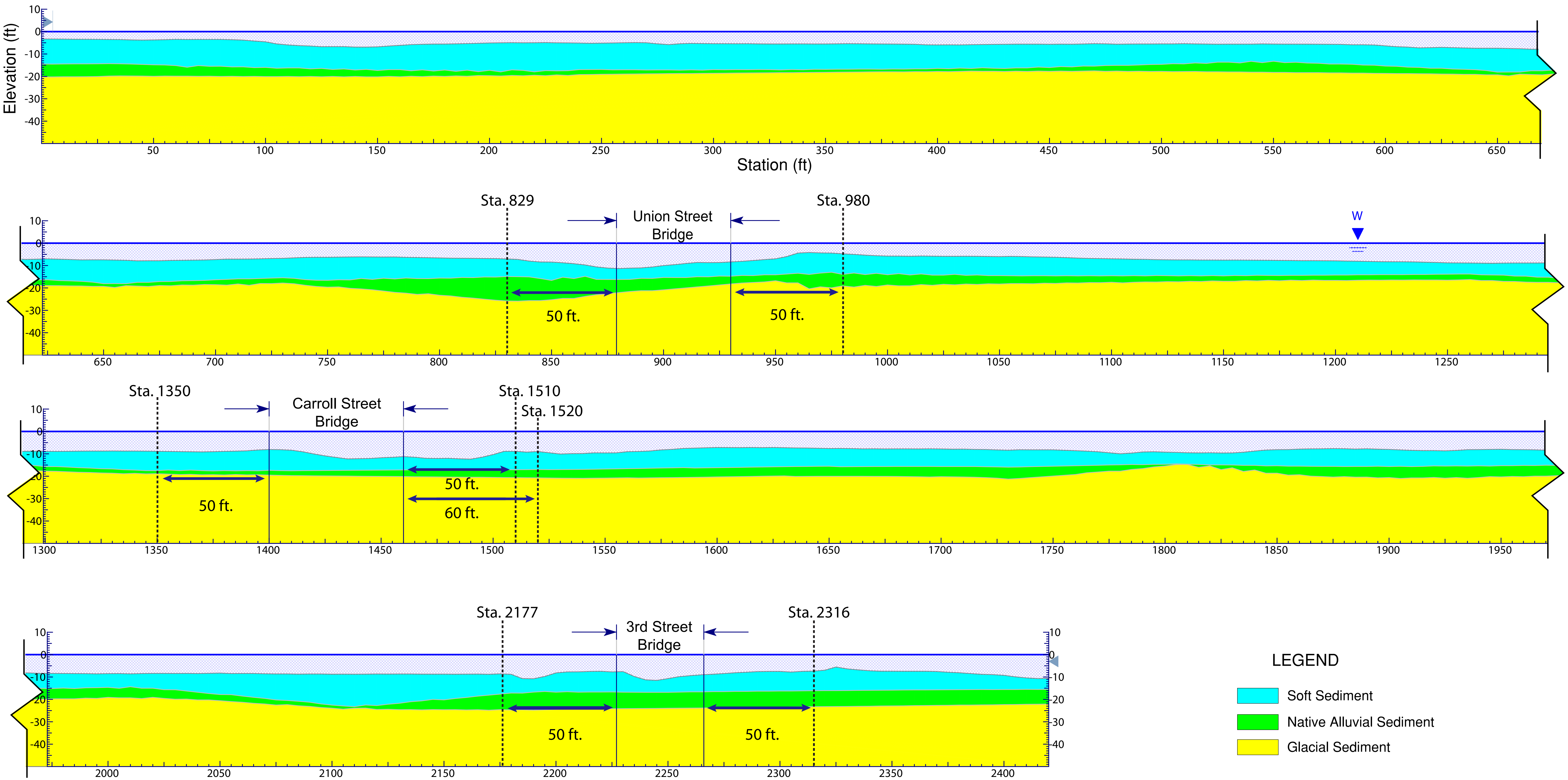
Ewing, NJ | August 2016

Figure 8a



Notes:
1. The soft sediment, native alluvial sediment and glacial deposit interface elevations were obtained from the calculation package titled "Summary of Subsurface Stratigraphy" prepared by Geosyntec [Geosyntec, 2016b].
2. Static slope stability analyses for assumed dredge slopes were performed at Sta. 829, 980, 1350, 1510, 1520, 2177 and 2316.

Profile View of CS-B in RTA1 Showing Locations of Dredge Slope Stability Analyses

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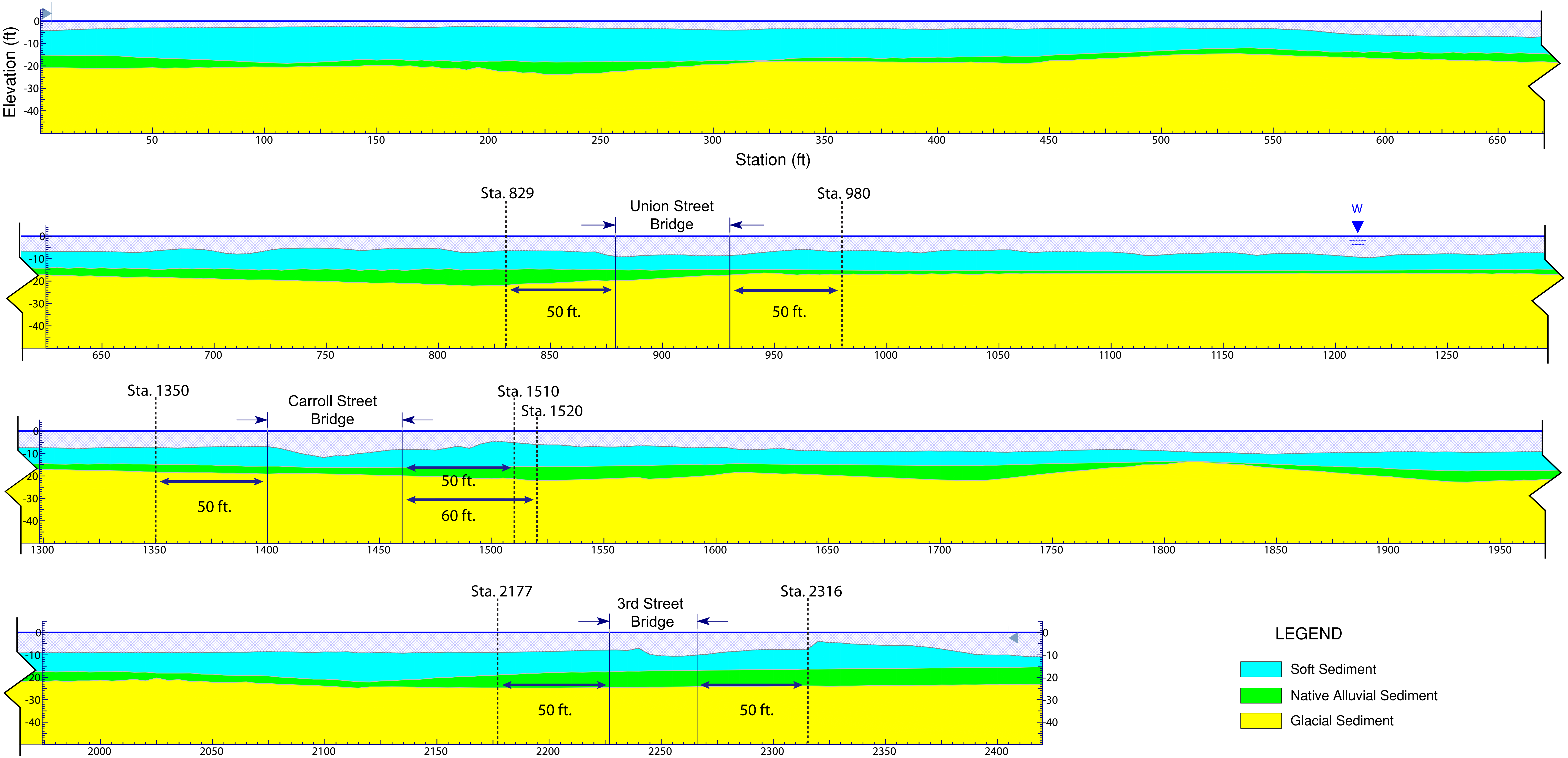
Figure 8b



Notes:

1. The soft sediment, native alluvial sediment and glacial deposit interface elevations were obtained from the calculation package titled "Summary of Subsurface Stratigraphy" prepared by Geosyntec [Geosyntec, 2016b].
2. Static slope stability analyses for assumed dredge slopes were performed at Sta. 829, 980, 1350, 1510, 1520, 2177 and 2316.

Profile View of CS-C in RTA1 Showing Locations of Dredge Slope Stability Analyses

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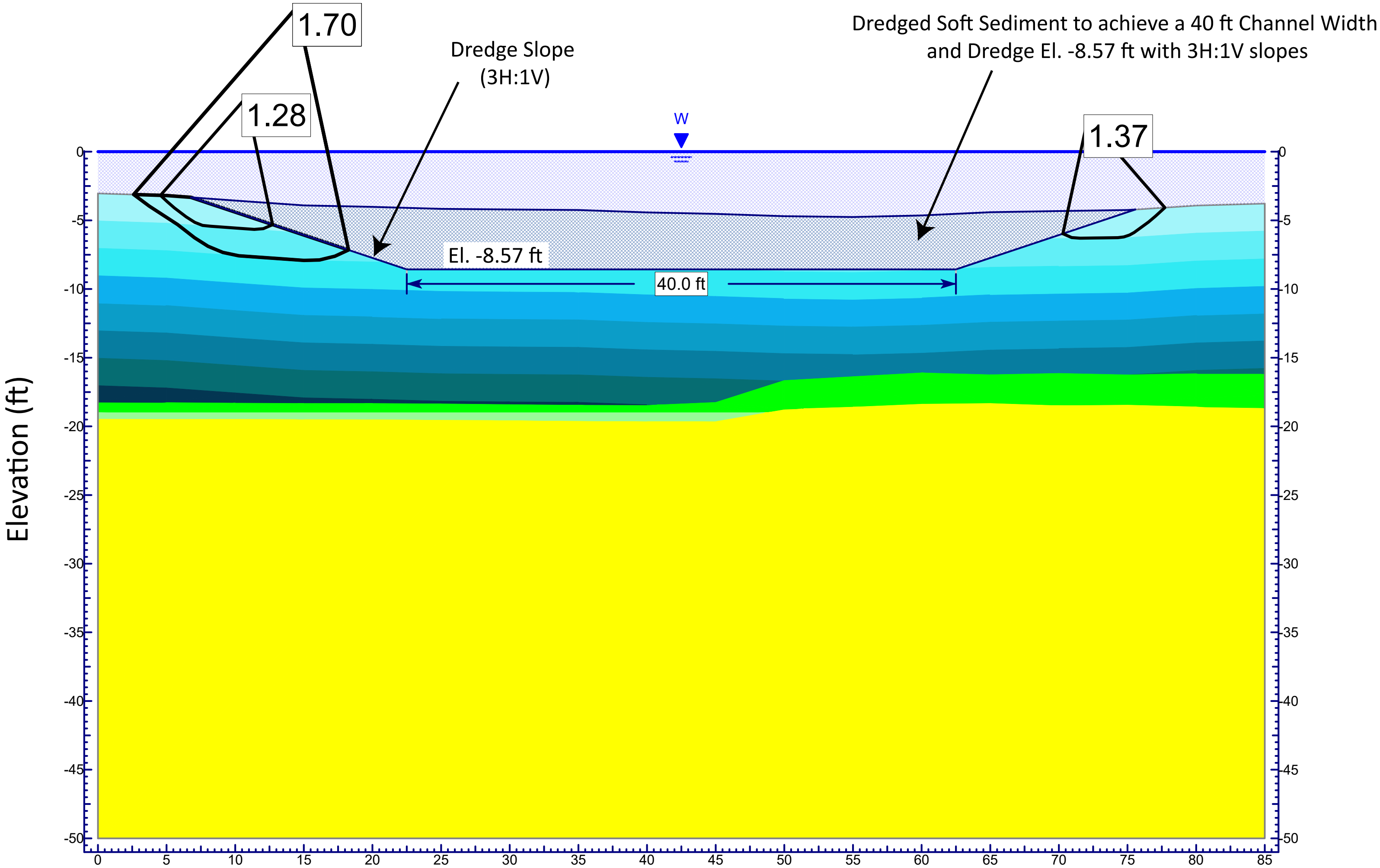
Figure 8c



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Glacial Deposit - D and UD		125	0	34
Soft UD: 0-2 ft		80	5.28	
Soft UD: 2-4 ft		80	15.84	
Soft UD: 4-6 ft		80	26.4	
Soft UD: 6-8 ft		80	36.96	
Soft UD: 8-10 ft		80	47.52	
Soft UD: 10-12 ft		80	58.08	
Soft UD: 12-14 ft		80	68.64	
Soft UD: 14-16 ft		80	79.2	
NAS UD (> El. -19 and < El. -26)		115	500	
NAS UD (in-between El. -19 ft and El. -26 ft)		115	250	

LEGEND:

D = Drained Shear Strength
UD = Undrained Shear Strength
Soft = Soft Sediment
NAS = Native Alluvial Sediment

Calculated FS (Short-Term Conditions) and Slip Surfaces for 3H:1V Dredge Slopes (Side Slope Stability) at CS-H in TB4

Gowanus Canal Superfund Site, Brooklyn, NY

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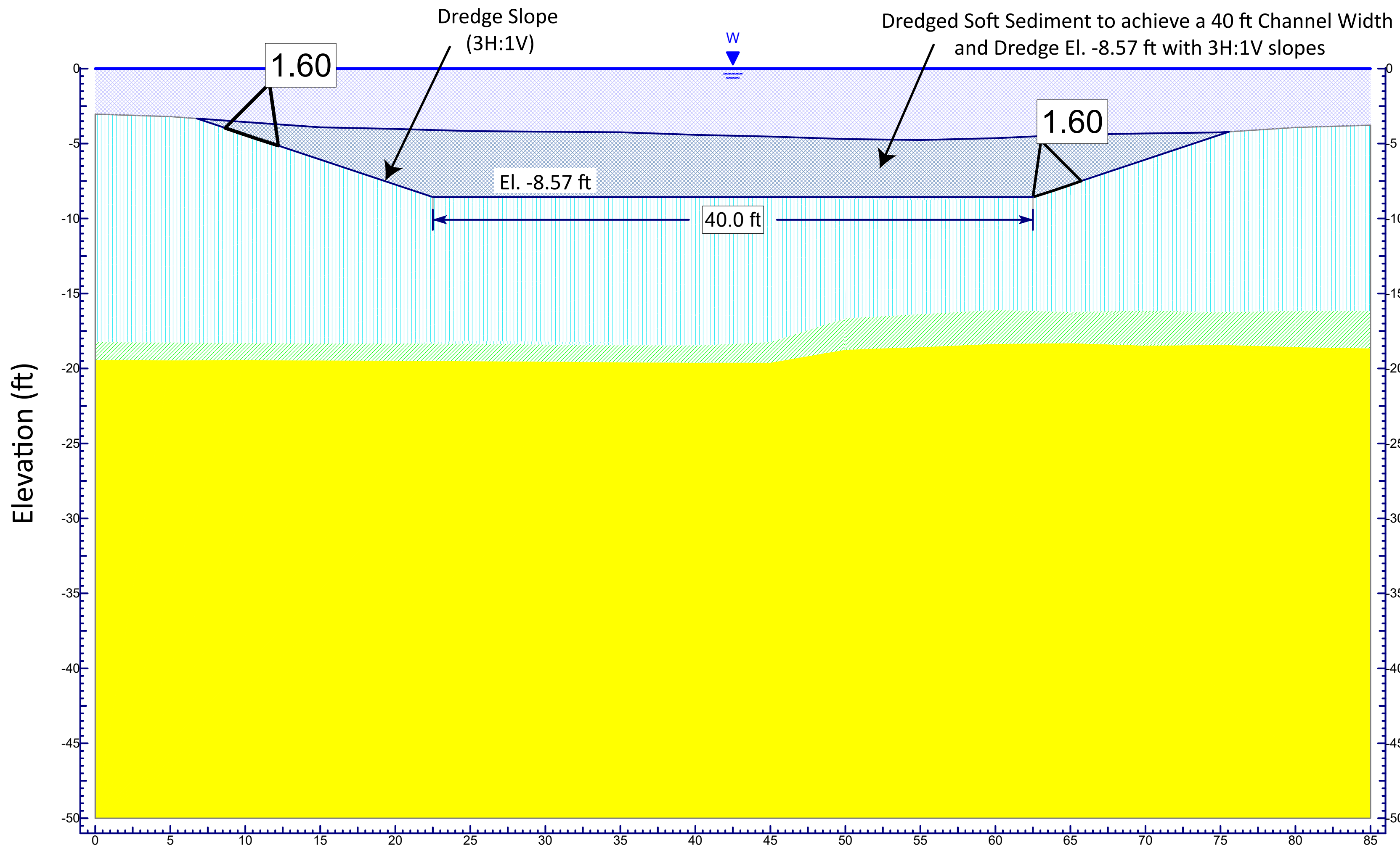
Figure 9



LEGEND:

D = Drained Shear Strength
UD = Undrained Shear Strength
Soft = Soft Sediment
NAS = Native Alluvial Sediment

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Glacial Deposit - D and UD		125	0	34
Soft Drained (Fully Softened)		80	0	28
NAS Drained (Fully Softned)		115	0	28

Calculated FS (Long-Term Conditions) and Slip Surfaces for 3H:1V Dredge Slopes (Side Slope Stability) at CS-H in TB4

Gowanus Canal Superfund Site, Brooklyn, NY

Gowanus Canal Remedial Design Group

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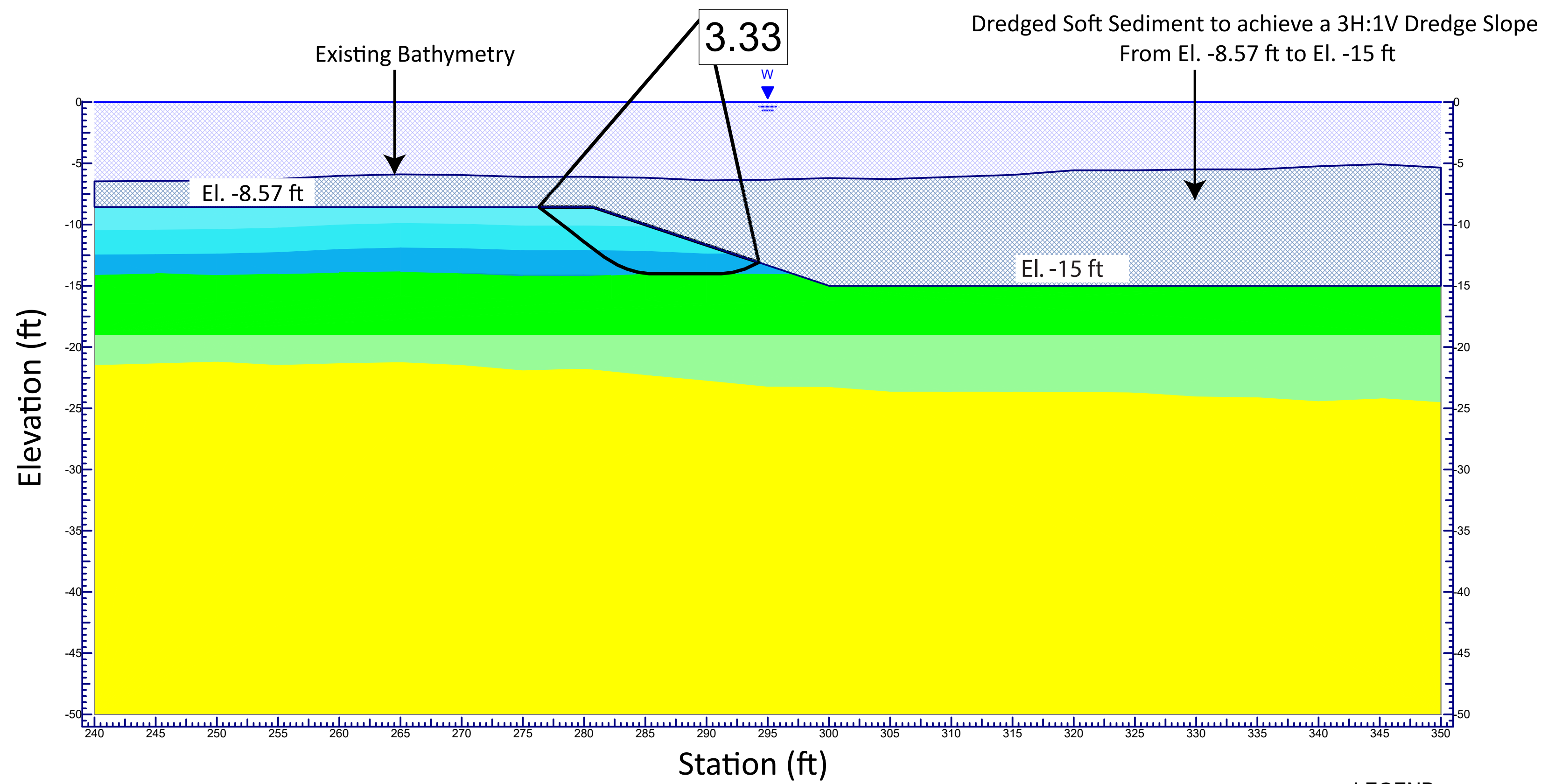
Figure 10



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Glacial Deposit - D and UD		125	0	34
Soft UD: 2-4 ft		80	15.84	
Soft UD: 4-6 ft		80	26.4	
Soft UD: 6-8 ft		80	36.96	
Soft UD: 8-10 ft		80	47.52	
NAS UD (> El. -19 and < El. -26)		115	500	
NAS UD (in-between El. -19 ft and El. -26 ft)		115	250	

LEGEND:

D = Drained Shear Strength
UD = Undrained Shear Strength
Soft = Soft Sediment
NAS = Native Alluvial Sediment

Calculated FS (Short-Term Conditions) and Slip Surfaces for a 3H:1V Dredge Slope (Along Canal Slope) at CS-I in TB4

Gowanus Canal Superfund Site, Brooklyn, NY

Gowanus Canal Remedial Design Group

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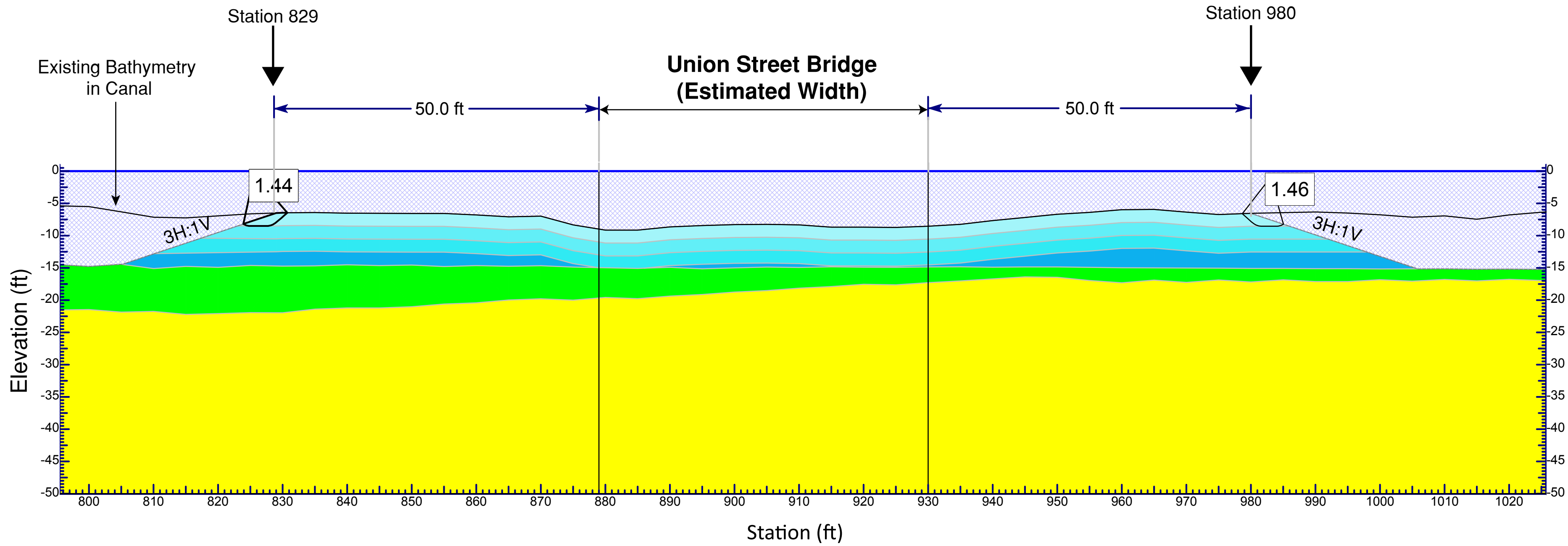
Figure 11



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Glacial Deposit D and UD		125	0	34
Soft UD: 0-2 ft		80	5.28	
Soft UD: 2-4 ft		80	15.84	
Soft UD: 4-6 ft		80	26.4	
Soft UD: 6-8 ft		80	36.96	
NAS UD (> El. -20 ft)		115	250	

LEGEND:

D = Drained Shear Strength
UD = Undrained Shear Strength
Soft = Soft Sediment
NAS = Native Alluvial Sediment

Notes:

1. The soft sediment, native alluvial sediment and glacial deposit interface elevations were obtained from the calculation package titled "Summary of Subsurface Stratigraphy" prepared by Geosyntec [Geosyntec, 2016b].
2. The above figure shows the calculated FS for short term conditions (i.e., using undrained shear strength properties). The calculated FS for this section for long-term conditions is 1.53

Calculated FS (Short Term Conditions) for Dredge Slopes (Along Canal Slope) at CS-C Near Union Street Bridge in RTA1

Gowanus Canal Superfund Site, Brooklyn, NY

Gowanus Canal Remedial Design Group

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Figure 12

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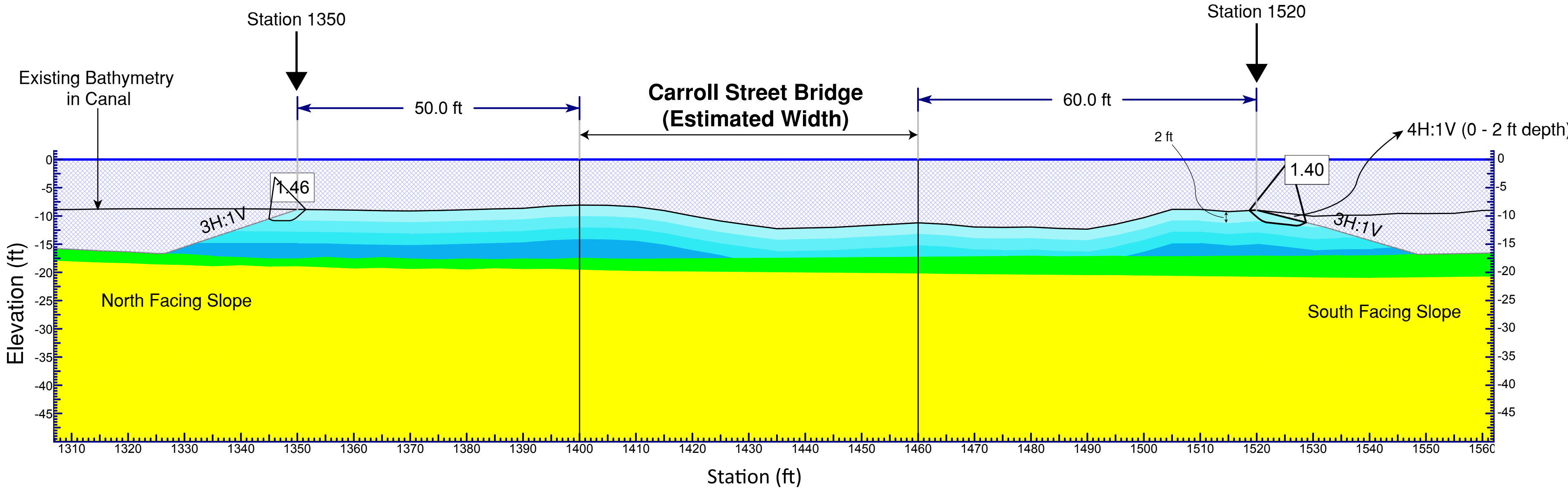

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Glacial Deposit D and UD		125	0	34
Soft UD: 0-2 ft		80	5.28	
Soft UD: 2-4 ft		80	15.84	
Soft UD: 4-6 ft		80	26.4	
Soft UD: 6-8 ft		80	36.96	
NAS UD (> El. -20 ft)		115	250	

LEGEND:

D = Drained Shear Strength
UD = Undrained Shear Strength
Soft = Soft Sediment
NAS = Native Alluvial Sediment

Notes:

1. The soft sediment, native alluvial sediment and glacial deposit interface elevations were obtained from the calculation package titled "Summary of Subsurface Stratigraphy" prepared by Geosyntec [Geosyntec, 2016b].
2. The above figure shows the calculated FS for short term conditions (i.e., using undrained shear strength properties). The calculated FS for this section for long-term conditions is 1.53

Calculated FS (Short Term Conditions) for Dredge Slopes (Along Canal Slope) at CS-B Near Carroll Street Bridge in RTA1

Gowanus Canal Superfund Site, Brooklyn, NY

Gowanus Canal Remedial Design Group

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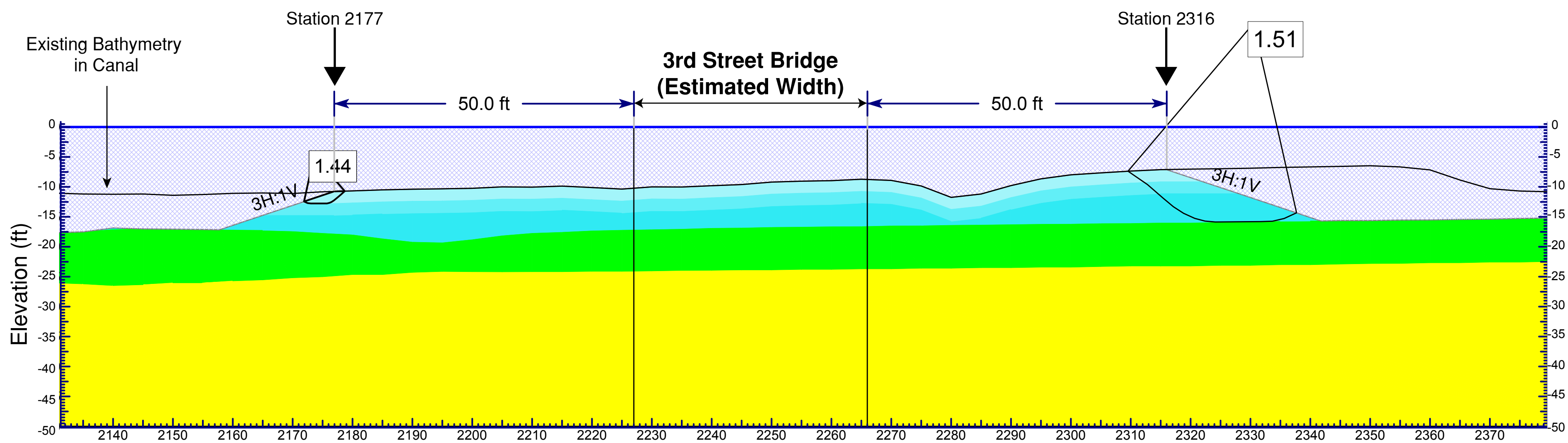
Figure 13



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Glacial Deposit D and UD		125	0	34
Soft UD: 0-2 ft		80	5.28	
Soft UD: 2-4 ft		80	15.84	
Soft UD: 4-6 ft		80	26.4	
NAS UD (> El. -20 ft)		115	250	

LEGEND:

D = Drained Shear Strength
UD = Undrained Shear Strength
Soft = Soft Sediment
NAS = Native Alluvial Sediment

Notes:

1. The soft sediment, native alluvial sediment and glacial deposit interface elevations were obtained from the calculation package titled "Summary of Subsurface Stratigraphy" prepared by Geosyntec [Geosyntec, 2016b].
2. The above figure shows the calculated FS for short term conditions (i.e., using undrained shear strength properties). The calculated FS for this section for long-term conditions is 1.53

Calculated FS (Short Term Conditions) for Dredge Slopes (Along Canal Slope) at CS-A Near 3rd Street Bridge in RTA1

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Figure 14